International Journal of Computer Science Engineering
and Information Technology Research (IJCSEITR)
ISSN(P): 2249-6831; ISSN(E): 2249-7943
Vol. 4, Issue 4, Aug 2014, 21-32

CONTROL OVERHEAD ENERGY EFFICIENT CLUSTER BASED ROUTING ALGORITHM IN MANET

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ABSTRACT

Clustering in MANET is a key technique for extending the lifetime of a network by reducing energy consumption. This also increase network's capacity, reduces the routing overhead and make it more scalable when nodes are in large number and highly mobile. In a cluster, clusterhead store and manage routing information related to its cluster member. Because of frequently changes in clusterheads leads to loss of routing information stored that affect the protocol and makes cluster structure unstable. In MANET nodes have limited battery resources so it is necessary that protocol must minimize the energy cost of a node at the time of cluster formation. Here we propose a new clustering algorithm name "control overhead & energy efficient clustering" algorithm. This algorithm focuses on cluster formation & its maintenance. It keep cluster head alive by choosing another clusterhead before it dead by predefined threshold value of energy. When two cluster head across each present cluster head will drop its position only when its energy value cross the threshold value that we have defined earlier. By this cluster structure can be more stable to prevent loss of routing information which gives better performance of the network.

KEYWORDS: MANET, Clustering, CBRP, Cluster Head, Node Energy

INTRODUCTION

In the case of MANET, dynamic topology is the most important issue for which a lot of techniques are developed to mitigate the problems. However, it has been proved that a flat structure exclusively based on proactive or reactive routing schemes cannot perform well in a large dynamic MANET. In other words, a flat structure encounters scalability problems with increased network size, especially in the face of node mobility at the same time. This is due to its intrinsic characteristics. The communication overhead of link-state proactive routing protocols is O (n2), where n is the total number of mobile terminals in a network. In reactive routing scheme, the control packets flood over the network and the route setup delay becomes considerably high in the existence of both, a large number of nodes and high mobility. [1, 2]

In MANETs, when network's size exceeds a certain threshold decreases the performance, resulting in many routing algorithms performing only when network's size is small. To overcome bandwidth and battery power limitations, and reduce routing overhead, it is mandatory to make network organization smaller and manageable. A clustering architecture provides solution for the Problem in MANET environments: network scalability, fault tolerance and reduction of communication overheads. [1]

The aim of our work is to improve efficiency of routing, and to minimize flooding messages. It is important that cluster formation and maintenance should not be costly, in terms of resources used such as Signal Strength, battery power

etc. else, the purpose of clustering is overwhelmed. In this paper, we have tried to present an algorithm that leads to power efficient and signal efficient cluster maintenance and cluster formation, which efficiently uses MANET resources.

RELATED WORK

Routing Protocols

In accordance with routing-driven model, Ad Hoc network routing protocols can be divided into table-driven routing protocols (such as DSDV protocol [3]) and on-demand routing protocols (such as AODV protocol [4]). According to differences in network topology, they can also be divided into flat routing protocols and cluster routing protocols. Table-driven routing protocols, also known as proactive routing protocols have the disadvantage that in the large network or fast topology variation situation, a large number of topology updates costs an excessive amount of resources and decreases system efficiency, because each node is required to maintain routing information in real time. On-demand routing protocols are passive routing protocols, in which the node is not usually necessary to maintain real-time routing table, only when the node has data to be sent the route discovery mechanism is activated to search destination route.

The routing protocols based on clustering mechanism have CBRP, CEDAR and HSR, etc. CEDAR (Core-Extraction Distributed Ad Hoc Routing Algorithm) [5] is a QoS routing algorithm of cluster-based structure. Its advantage is able to support the QoS requirements of real-time business. Its disadvantage is that routing update overhead sharply increases with the increase of the network size. In addition, the scalability of the network is bad. CGSR (Clusterhead Gateway Switch Routing) [6] is in agreement on the basic DSDV protocol combining hierarchical routing mechanism. In the actual use, CGSR is more effective than flat routing protocols.

CBRP Protocol

CBRP (Cluster Based Routing Protocol) [7] is a cluster on-demand source routing protocol, having many similarities with the Dynamic Source Routing Protocol (DSR). By partition the network into small group of nodes it forms clusters at the time of route discovery, protocol minimize the flooding traffic and speed up the process. Each node broadcast HELLO messages to maintain 2-hope topology. Compared with other routing algorithms, CBRP has small routing control overhead, less network congestion and search time during routing. In CBRP, clusterhead manages all cluster numbers all the information and behavior in each cluster, and finds the adjacent clusters for routing through the gateway node.

In addition every node maintain its neighbor table and broadcast HELLO message periodically to enable each node to get information about all unidirectional and bi-directional links within 2-hops. This information is kept in a data structure. After checking this database, a node can tell who is its 2-hop bidirectional linked neighbors and through which intermediate nodes can be reached.

Lowest-ID algorithm is used for the clusterhead election in CBRP.

The route discovery is the mechanism whereby a node S wishing to send a packet to a destination D obtains a source route to D. The way S finds a route (or multiple routes) to D is also done by flooding. However, because of the clustering approach the number of times nodes are disturbed are much less in general. Essentially, in route discovery, only cluster heads are flooded with Route Request Packets (RREQ) in search for a source route.

When the target of the request, node D, receives the RREQ, D sends out a Route Reply Packet (RREP) to S as a reply. When S receives RREP, it will get all calculated route, a sequence of addresses of the hop-by-hop source route.

Signal and Energy Efficient Clustering (SEEC)

In this scheme, author proposes a "Signal and Energy Efficient Clustering (SEEC)" algorithm based on signal strength and energy level of nodes in MANET to improve system performance. The algorithm focuses on cluster head formation and maintenance, and prevents death of cluster head by making another cluster node as the cluster head when power level falls below certain threshold value.

The main drawback of routing protocol is that the Cluster head dies of due to extra power dissipation. The proposed algorithm takes care of cluster head formation and keeps it alive after initial cluster formation and avoids re-election of cluster head when signal strength or power level reaches certain minimum threshold value. There is no need for explicit message passing during cluster maintenance. SEEC maintains two tables for each cluster head they are 'Cluster Head Table' and 'Routing Table' and one 'Neighbor table' by each nodes in cluster.

Cluster Formation in SEEC

During the time of cluster formation each node broadcast a HELLO message specifying its ID, Signal Strength, power level among cluster nodes. Each node after receiving the HELLO messages will compare its signal strength with others. The node having the highest signal strength declares itself as the header and will broadcast a decision message specifying its ID. After initial cluster formation & electing a cluster head our job is to take care cluster head alive & to avoid reelection of cluster head

In SEEC algorithm [8] which is based on signal strength and energy level of nodes, and both play important role in choosing the new cluster head, and also before the existing cluster head's power level falls below certain threshold value, the next value in the cluster head table will take place as a new cluster head of that cluster.

The drawback is that in SEEC approach, it is using one additional table named HTABLE which create additional load on Cluster head to maintain that table. And after adding two additional parameters 'signal strength' & 'power level', size of hello packet increases. This things make effect on Chead performance and because of handling its own cluster member table and HTABLE, load on Chead will be increase. Which effect its life also and if cluster head life affect networks life also affect. At the same time when another cluster head across the cluster head and if its signal strength & energy level is greater than to the present cluster head, at that moment the existing cluster head have to drop its position. This situation can be the reason of performance degradation because of changing cluster head in inefficient way.

PROPOSED APPROACH – COEEC ALGORITHM

In the previous approach "**Signal and Energy Efficient Clustering**" we have seen that the algorithm focusing on the shorter life span of the cluster head. Cluster head dies of due to extra power dissipation is preventing the death of the cluster head by making another node as the cluster head when power level falls below certain threshold value. The proposed algorithm takes care of cluster head formation and keeps it alive after initial cluster formation and avoids re-election of cluster head when signal strength or power level reaches certain minimum threshold value.

At the same time due to mobility of nodes clustering algorithm involve frequent re-clustering. Same issue come in when a new cluster head with more signal strength & power level come in a cluster, it challenge the present cluster head. This result frequent cluster head changes in the cluster.

To come out with the frequent cluster head re-election we have propose a solution name "Control Overhead & Energy Efficient Clustering (***COEEC***)". The proposed algorithm will form a cluster based on highest energy node present in neighbor nodes. By defining threshold value we can keep our cluster head alive before it dead. So that it is possible to avoid re-election of cluster head which enhance the network performance and its life and reduce overhead.

Modifications in Neighbor Table

In MANET all nodes have their neighbor table, which gives information to a node that how many nodes are connected with it. Node broadcast HELLO messages periodically after every HELLO_INTERVAL seconds a nodes HELLO message contain its 'Cluster Adjacency Table' and Neighbor Table'. 'Figure 1' shows the new modified message format of Neighbor Table, where with the existing data structure one more new fields are added which is 'neighbor node energy', this node energy help us to choose new cluster head which consist highest energy among all the node in the table.

Table 1: Format for Neighbor Table

Neighbor id	Neighbor Status	Link Status	Neighbor Node Energy

Cluster Formation

At the time of cluster formation every node periodically sends Hello messages. After receiving that Hello message all nodes update their neighbor table, in which we also adding node's energy also. Neighbor table shows neighbor node id, neighbor node status, its link status and neighbor node energy, this neighbor table update after every hello interval. Initially cluster head choose on the bases of LID approach, but after some time when we need to choose a new cluster head, node with the max energy in the table will be selected as new cluster head and will broadcast a decision message specifying its ID. All the nodes will agree on the decision. After initial cluster formation & electing a cluster head our job is to take care cluster head alive & to avoid reelection of cluster head when battery power level certain minimum threshold value.

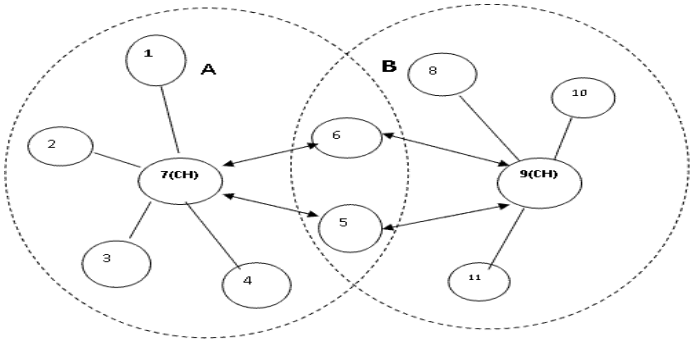

Figure 2: Cluster Architecture

As shown in fig 2, cluster architecture where 'node 7' & 'node 9' are cluster heads of cluster A & B C respectively. 'Node 6' and 'node 5' act as cluster gateways, and rest of them are cluster nodes. Intra cluster communication between two nodes takes place via cluster head, for example communication between 'node 1' and 'node 3' takes place via

cluster head 'node 7'. Inter-cluster communication between two nodes take place via cluster gateway with the help of cluster heads of the two clusters.

As shown in Fig 3 it represent Neighbor table maintained by each CH of cluster in network. Neighbor table of cluster head node stores node id, node status, link status, and energy level 'EL'. EL will help in cluster head election in a cluster. Certain threshold values ethresh for energy level are decided. If energy level falls below their respective threshold value then node with the maximum energy present in the neighbor table becomes the cluster head and then the routing table is updated. By this maximum energy node in the table among all the other cluster member, so it will be selected as CH of the cluster. This algorithm initially makes the node with the lowest ID as the cluster head. Here in this fig 4, we have shown two cluster head table based on the cluster structure given in fig 3. Where node 7 & node 9 are two cluster head of cluster A and B respectively. Both clusters are connected through gateway 5 & 6. Here in the table every CHead consist information about their cluster members and their energy level. Value of energy change as per the nodes movements so as the table also update periodically.

Table 2: Table for Each Cluster Head

Neighbor Table of 7 in Cluster 'A'			
Node Id	**Neighbor Status**	**Link Status**	**EL%**
7	Cluster head	bidirectional	*89*
4	Cluster member	bidirectional	60
6	Cluster member	bidirectional	68
2	Cluster member	bidirectional	70
1	Cluster member	bidirectional	81
5	Cluster member	bidirectional	72
3	Cluster member	bidirectional	43

Table 3: Table for Each Cluster Head

Neighbor Table of 9 in Cluster 'B'			
Node Id	**Neighbor Status**	**Link Status**	**EL%**
9	Cluster head	bidirectional	*81*
8	Cluster member	bidirectional	58
6	Cluster member	bidirectional	72
10	Cluster member	bidirectional	78
5	Cluster member	bidirectional	60
11	Cluster member	bidirectional	71

Proposed algorithm ***COEEC's*** focus on to cluster formation and cluster maintenance. Energy plays important role if we choose a cluster head based on energy. If cluster head have maximum energy it can maintain its cluster and cluster member for long time period. This algorithm will choose a node as a Chead which has maximum energy value, also it set a 'Ethresh' threshold value which keep Chead alive until its energy value falls below to the predefined threshold. At the time of cluster maintenance when CHead of different cluster enter in a cluster consist more energy level as compare to present CHead of cluster, at that point of time present CHead has to drop its position from CHead & new CHead will rule the Cluster. This is a common problem we are facing when two CH across each other one of them have to drop from its position because at the same time two nodes cannot play the same role of CH.

To overcome from this problem we have proposed an idea by which when new CHead come in cluster first we compare the values of both the CHeads ie. Energy level. If old CHead have still max value from the other CHead, then

there is no change in CHead & new CHead will drop its position prom CH and act as an ordinary node in the cluster its entries will add into the NTABLE of CHead and table will update accordingly. But if new CHead have max value from the old CHead at that time the entry of the new CHead will add in the

NTABLE and table will update. After it compare the energy level of old CH with the predefined threshold values. If the energy level of CHEAD falls below their respective threshold value then next node with maximum energy in the NTABLE becomes the new cluster head. when old CHead drops it position new node will selected as CHead.

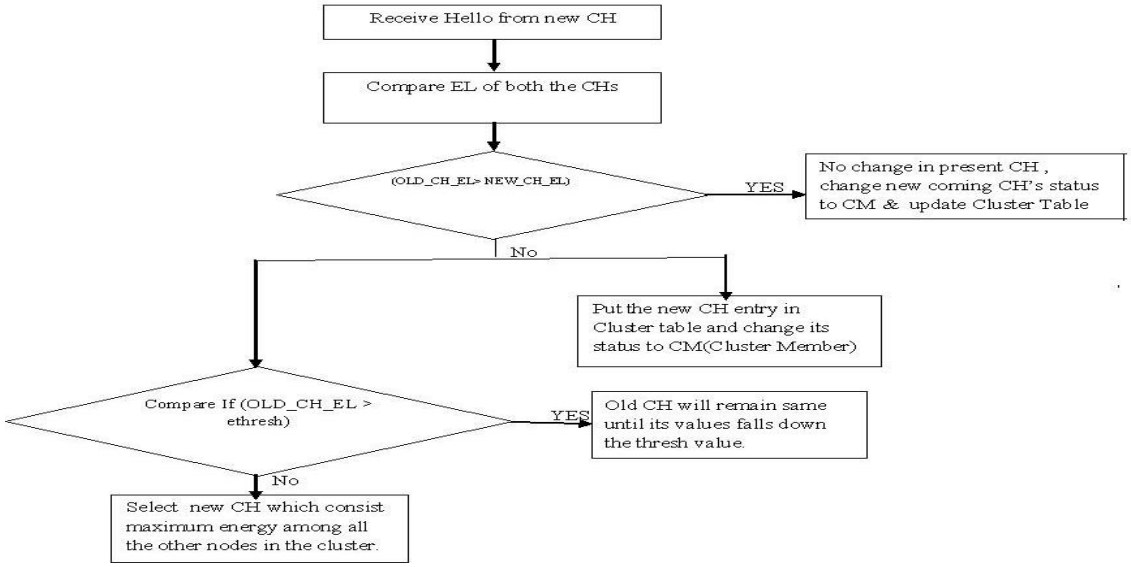

Figure 4: Cluster Maintenance Using COEEC Algorithm

PROPOSED ALGORITHM

Cluster Formation

- Begin procedure
- Initially CH will be choose on the basis of LID(*all nodes are at same energy level*)
- Make NTABLE(NID,NS,LS,EL) (every CH will maintain its cluster member table along with their energy values)
- When present cluster head's energy value falls below to predefined threshold value**,** it looks for node with maximum energy in the table.
- After finding such node it will selected as new CHead before the CHead dead and the process will continue.
- New Chead will broadcast a decision message that it has been selected as new Chead.
- End procedure

Cluster Maintenance – at the Time of Two Cluster Head across Each Other

- **CH will Check Status of a New Node Coming into the Cluster**

  if(status != CH)

  { add its entry to NTABLE}

else

{

compare old CH with new CH

{

if ((old_ch_el>new_ch_el) && (old_ch_el >=.20))

{no change in old CH, new ch status will now CM}

else

{ put new CH entry at in NTABLE & change status to CM}

}

end

- **if (old_ch_el>Ethresh)**

  {old CH will remain same}

  else

  {node with max energy in table choose as new CH}

  end

- **Update the NTABLE & send msg to the other nodes**
- **End**

PERFORMANCE EVALUATION

The performance of COEEC algorithm it is evaluated using NS2[9] and compared with Lowest Id(LID) algorithm in CBRP protocol[7]. For this we calculate node energy for Clusterhead selection, to formulate a cluster and select cluster head which consist maximum energy among all the neighbor node. After forming a Cluster for its maintenance we have predefine a threshold value of energy so that before cluster head energy go below to that threshold value it will change its position immediately and then node with max energy will get select as a new cluster head. By this we can choose new cluster head before it dead and also avoid re-clustering to make cluster more stable for increasing network life.

Simulation Parameters

The simulation parameter has shown in Table 1. Here, we designed and implemented our test using Network Simulator (NS-2) to test the performance of both Routing algorithms.

Table 1: Simulation Parameter

Parameter	Values
Simulation Duration	200 s
Topology Area	1000m x 1000m
Number of nodes	50/10-150
Mobility Speed	10(m/s)

Table 1: Contd.,	
Pause Time	2-30 sec/2 sec
Mobility Model	Random waypoint
Packet rate	4packets/s
Traffic Type	Constant Bit Rate

Simulation Results

We simulated COEEC (along with CBRP) using NS2. Here we present the simulation results and compare COEEC with CBRP protocol. In this scenario we change the number of nodes, increase pause time as well.

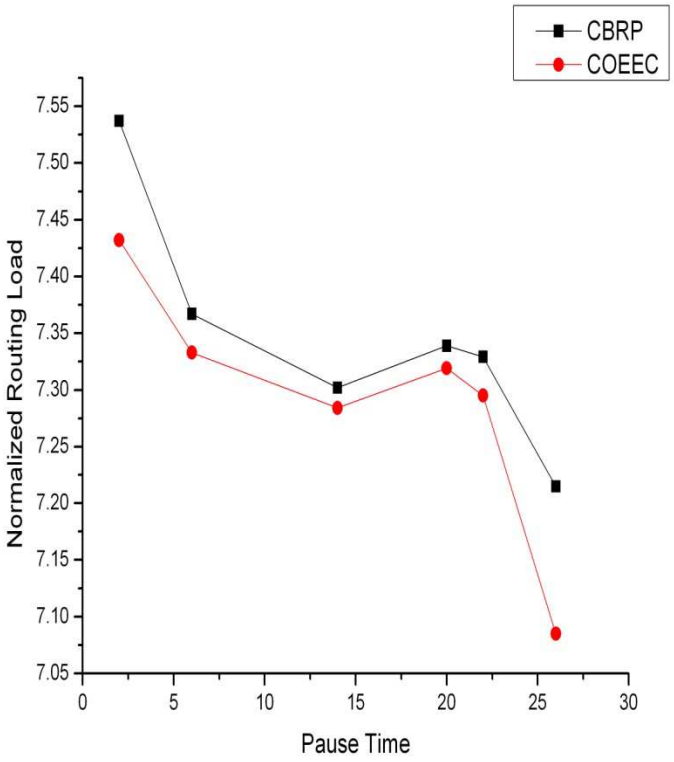

Figure 5: Normalized Routing Load vs. Pause Time

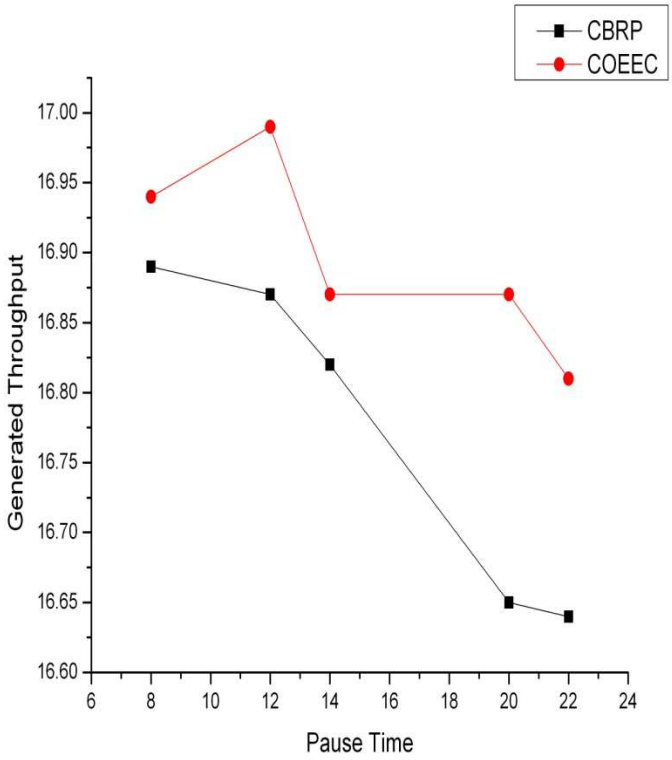

Figure 6: Generated Throughputs vs. Pause Time

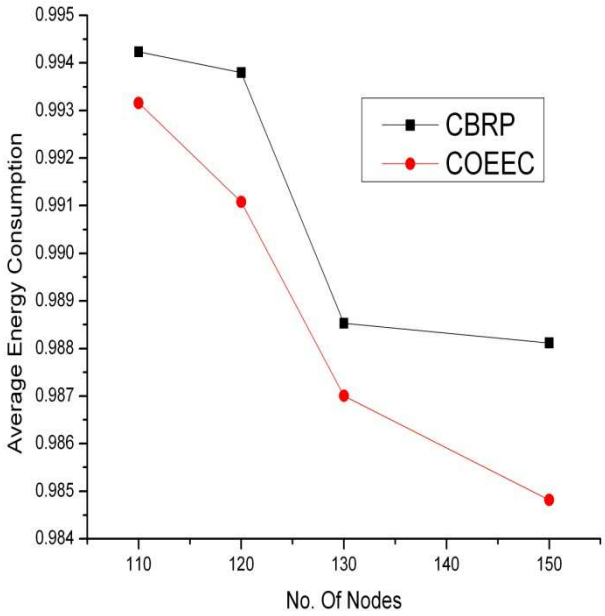

Figure 7: Average Energy Consumption vs. Number of Nodes

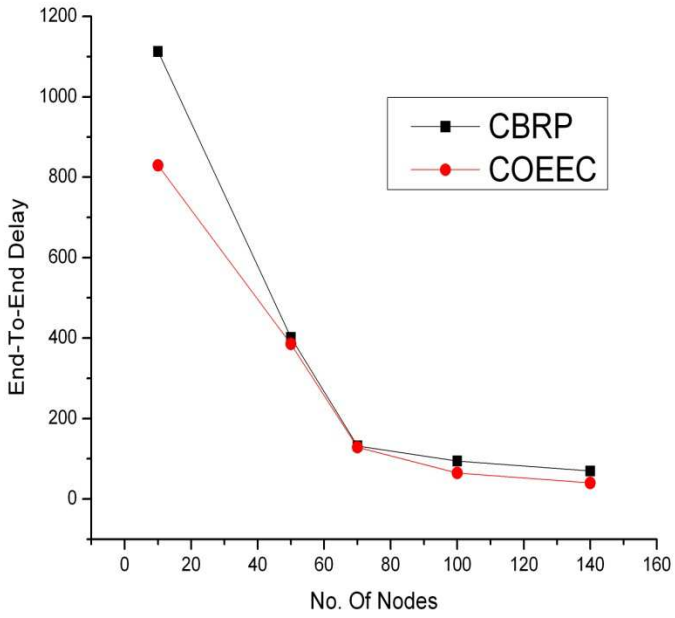

Figure 8: End-to-End Delay vs. Number of Nodes

The above figure shows that COEEC algorithm is perform better than in Clusterhead selection in CBRP protocol.

CONCLUSIONS

Proposed COEEC algorithm's basic idea is to form a clusterhead with maximum energy value, so that it can maintain its cluster for long time and the life of cluster can be increase. Also predefined a Ethresh values so that before Chead's energy falls below the threshold value it choose new cluster head immediately. One more goal is that when two cluster head cross each other in transmission range we can delay clusterhead change to avoid unnecessary clusterhead change and reduce overhead. Algorithm also avoids re-election of cluster head as it select new CHead before CH dead so that it can control overhead. Algorithm proposed in this paper is feasible in the practical world and expecting longer network lifetime and will consume less energy & less overhead. Our future work is to simulate the proposed algorithm of the cluster head maintenance phase.

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